MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2017/2018

DET5038 – POWER ELECTRONICS

(Diploma in Electronics Engineering)

12 MARCH 2018
2:30 PM –4:30 PM
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **8** pages (**6** pages with **5** questions and **2** pages for appendix).

2. Answer ALL questions. All necessary working steps must be shown.

3. Write all your answers in the answer booklet provided.

QUESTION 1 [20 marks]

(a) State the four ideal characteristics of controllable switches and briefly explain each of the characteristics.

(10 marks)

(b) Based on Figure 1, explain in detail the operation of the Full Wave Rectifier circuit with resistive load for both positive and negative cycle of the AC supply voltage. Draw the expected output voltage waveform.

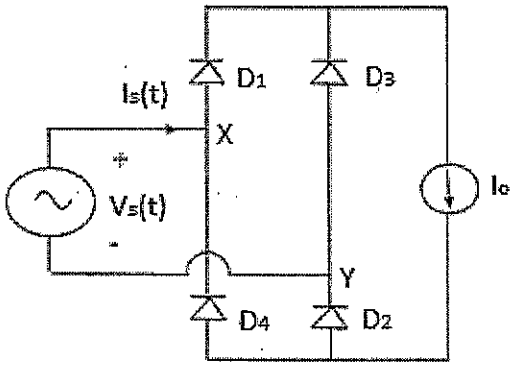

Figure 1

(10 marks)

Continued ...

QUESTION 2 [20 marks]

(a) Draw the schematic diagram of a Buck-Boost DC-DC Converter. State its main advantage over the normal Buck Converter and Boost Converter.

(6 marks)

(b) Based on Figure 2, explain in detail the operation of the Full Bridge Inverter with resistive in series with inductive load for converting a DC voltage supply to an AC output waveform. Draw the expected output voltage waveform and output current waveform.

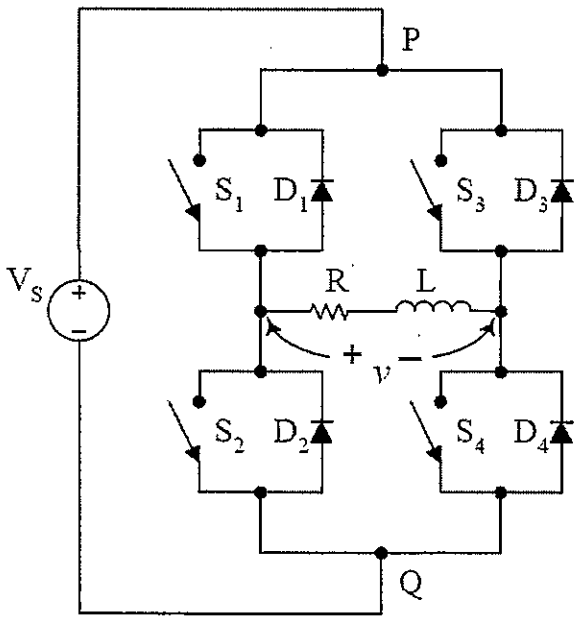

Figure 2

(10 marks)

(c) State the 4 drawbacks of a switch-mode operation.

(4 marks)

Continued ...

QUESTION 3 [20 marks]

A power BJT is used as a switch to energize a resistive load, as shown in Figure 3. Assume that the transistor on state time is twice that of the off state time at a switching frequency of 400 kHz. By using the provided data, find :

(a) On state collector current, $I_{c(on)}$.

(2 marks)

(b) Static power loss, P_{static}.

(14 marks)

(c) Dynamic power loss, $P_{dynamic}$.

(2 marks)

(d) Total power loss, P_{total}.

(2 marks)

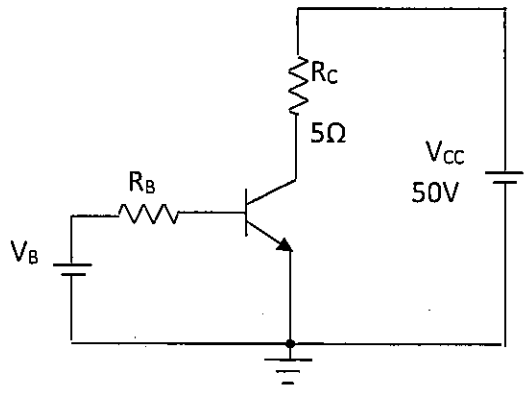

Figure 3

$V_{CE(sat)} = 5.5$ V

$V_{BE(sat)} = 3.0$ V

$V_{BE(on)} = 0.7$ V

$I_{C(leak)} = 5$ μA

$\beta = 20$

$\tau_{on} = \tau_{off} = 0.5$us

Continued ...

QUESTION 4 [20 marks]

(a) A half wave diode rectifier has an AC input voltage of 250V with the output terminal connected to a 150 Ω resistor. Assume that the diode is ideal. Calculate the:

(i) Average output voltage.
(2 marks)

(ii) RMS output voltage.
(2 marks)

(iii) Ripple voltage.
(2 marks)

(iv) Ripple voltage factor
(2 marks)

(v) State two disadvantages of half wave rectifier.
(2 marks)

(b) A converter is operating from 5 V DC voltage source and it supplies 20 W to a 5 Ω load resistor under continuous conduction mode at the frequency of 40 Hz. Assume that the filter capacitance is very large and neglect the ON state voltage drop across the diode. Compute for the following:

(i) The output voltage and duty ratio. State the type of converter.
(4 marks)

(ii) The minimum inductance value needed for this converter.
(3 marks)

(iii) The output voltage ripple produced by 5mF capacitor.
(3 marks)

Continued ...

QUESTION 5 [20 marks]

(a) A single-phase half-bridge inverter has a dc input voltage of $V_s = 500 \ V$. Determine the following :

(i) The RMS output voltage of the fundamental component.

(1 mark)

(ii) The RMS output voltage.

(1 mark)

(iii) The RMS output voltage of total harmonic component.

(2 marks)

(iv) The harmonic factor of the 1st, 2nd and 3rd harmonic.

(2 marks)

(v) The total harmonic distortion.

(2 marks)

(vi) The voltage transfer ratio.

(2 marks)

Continued ...

(b) Figure 4 shows a resonant inverter circuit. The inverter is required to operate at a frequency of 10 kHz. The circuit turn off time is 25 μs and thyristor turn off time is 8 μs.

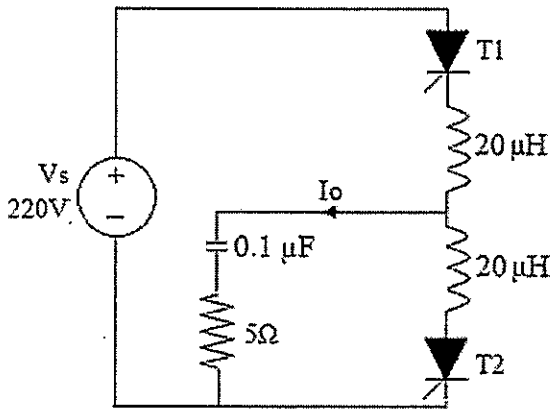

Figure 4

(i) State two limitations compensated by this inverter.

(4 marks)

(ii) Determine the maximum permissible output frequency, f_{max}.

(6 marks)

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APPENDIX

Table 1 Switching power loss of power BJT

	Resistive Load	Inductive Load
ON state	$P_{on} = [V_{CE(sat)} I_{C(on)} + V_{BE(on)} I_{B(on)}] \frac{t_{on}}{T}$	$P_{on} = [V_{CE(sat)} I_{C(on)} + V_{BE(on)} I_{B(on)}] \frac{t_{on}}{T}$
OFF state	$P_{off} = [V_{CC} I_{C(leak)}] \frac{t_{off}}{T}$	$P_{off} = [V_{CC} I_{C(leak)}] \frac{t_{off}}{T}$
Turn On	$P_{turn-on} = V_{CC} I_{C(on)} \frac{\tau_{on}}{6T}$	$P_{turn-on} = V_{CC} I_{C(on)} \frac{\tau_{on}}{2T}$
Turn Off	$P_{turn-off} = V_{CC} I_{C(on)} \frac{\tau_{off}}{6T}$	$P_{turn-off} = V_{CC} I_{C(on)} \frac{\tau_{off}}{2T}$

Table 2 Switching power loss of power MOSFET

	Resistive Load	Inductive Load
ON state	$P_{on} = I^2_{D(on)} R_{DS(on)} \frac{t_{on}}{T}$	$P_{on} = I^2_{D(on)} R_{DS(on)} \frac{t_{on}}{T}$
OFF state	$P_{off} = I_{D(off)} V_{DD} \frac{t_{off}}{T}$	$P_{off} = I_{D(off)} V_{DD} \frac{t_{off}}{T}$
Turn On	$P_{turn-on} = \frac{V_{DD} I_{D(on)} \tau_{on}}{6T}$	$P_{turn-on} = \frac{V_{DD} I_{D(on)} \tau_{on}}{2T}$
Turn Off	$P_{turn-off} = \frac{V_{DD} I_{D(on)} \tau_{off}}{6T}$	$P_{turn-off} = \frac{V_{DD} I_{D(on)} \tau_{off}}{2T}$

Table 3 Useful equations of DC to DC converters

Buck Converter	Boost Converter	Buck-Boost Converter
$V_o = DV_s$	$D = 1 - \frac{V_s}{V_o}$	$D = \frac{V_O}{V_s + V_O}$
$I_L = \frac{V_o}{R}$ $(\Delta i_L)_{close} = \frac{V_s - V_o}{L} DT$ $(\Delta i_L)_{open} = -\frac{V_o}{L}(1-D)T$	$I_L = \frac{V_s}{R(1-D)^2}$ $(\Delta i_L)_{close} = \frac{V_s}{L} DT$ $(\Delta i_L)_{open} = \frac{V_S - V_o}{L}(1-D)T$	$I_L = \frac{V_s D}{R(1-D)^2}$ $(\Delta i_L)_{close} = \frac{V_S}{L} DT$ $(\Delta i_L)_{open} = -\frac{V_o}{L}(1-D)T$
$L = \frac{(1-D)R}{2f}$	$L = \frac{D(1-D)^2 R}{2f}$	$L = \frac{(1-D)^2 R}{2f}$
$C_{min} = \frac{1-D}{8Lf^2 \frac{\Delta V_o}{V_o}}$	$C = \frac{D}{Rf \frac{\Delta V_o}{V_o}}$	$C = \frac{D}{Rf \frac{\Delta V_o}{V_o}}$